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USE OF AERIAL-PHOTOGRAPHY SURVEYS IN DRAWING UP PLANS FOR HYDROELECTRIC POWER STATIONS

- USSR -

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FOREWORD

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A wide range of measures for the complete utilization of water resources has been worked out in the planning of hydroelectric power stations. Besides the development of the water power of rivers, measures for the reconstruction of water transport, irrigation, etc., are provided for in the plans.

Great reservoirs are being created in connection with the construction of hydroelectric power stations on the rivers of the plains. The creation of reservoirs makes necessary measures for the rebuilding of inundated objects removed from the zone of the reservoir, and for preparation of the bed of the reservoir for filling and exploitation. The following data will give an idea of the scale of such measures: in connection with the construction of the Kremenchugskiy reservoir on the Dnieper River 147,000 people had to be resettled, and the volume of wood removed and cleared for the preparation of the bed of the reservoir for the Bratskaya Hydroelectric Power Station on the Angara River consisted of more than 40 million cubic meters.

Thus great national economic problems are solved in the planning and construction of hydroelectric power stations, and the sphere of projected studies embraces a large territory the extent of which in a number of cases has materially increased as a result of including in the planning the regions surrounding rivers.

The execution of varied research work and the establishment of a cartographic base for a very large territory are required in connection with the basic plans for a hydroelectric power station and the measures related to building a reservoir. The existing official maps on scales of 1:100,000 and 1:50,000 are not satisfactory for detailed planning. Therefore a scale of 1:25,000 with contours every 5 meters (every 2.5 meters on the gently sloping sides of the reservoir) was adopted as the basic scale for the topographic surveys of river valleys in designing hydroelectric power stations for the Hydroelectric Power Installations Planning

Trust. Sometimes a scale of 1:10,000 with contours every 2.5, 2, and 1 meter is used in the case of small reservoirs and rivers with a high economic potential.

Since 1951 topographic surveys of river valleys in connection with the planning of power stations have on the whole been executed by the Main Administration of Geodesy and Cartography (GUGK -- Glavnoye Upravleniye Geodezii i Kartografii) according to the technical specifications and within the periods approved by the Hydroelectric Installations Planning Trust. Some of the work on small reservoirs is done by its branches.

Topographic surveys of river valleys on a scale of 1:25,000 covered 170,000 square kilometers during the years 1951-1955; in the period 1956-1960 it is planned to survey approximately 360,000 square kilometers. The areas of the individual sections of the survey will be 25,000-40,000 square kilometers (the Sukona, Amur, Angara rivers, etc.).

While taking note of the very great contribution of the GUGK in providing cartographic material for the study and planning of hydroelectric power stations, it is necessary to point out several shortcomings in the provision of this material.

1. Official maps of river territories having different physical-geographical conditions and different degrees of economic potential are on one and the same scale -- 1:25,000, with contours every 5 meters. However, the requirements of the planning -- estimates of the water supply, determination of the natural indices of floods, designing protective and land-reclamation measures, the utilization of shallow areas, provision for navigation, etc. -- in a number of cases make it necessary to base the plans on maps of a larger scale, that is, 1:10,000, with contours every 2.5-2 meters, and sometimes even every meter. Surveys of river valleys on this scale are necessary for the plans for hydroelectric power stations on the rivers of European Russia, the Caucasus, and Central Asia.

However, maps of a scale greater than 1:25,000 are necessary only for certain parts of the reservoir, namely, the areas on the slopes of the reservoir lying in the tapering-out zone of the waterhead, including the parts affected by the washing of the reservoir, areas for navigation, etc. Therefore it is necessary to study the possibility of making maps on a scale of 1:25,000 and 1:10,000 from materials of one and the same flight.

2. It is necessary to facilitate the utilization of the intermediate products of aerial surveys -- aerial photographs, enlargements, mosaics, etc. The value of these materials in planning hydroelectric power stations is very great, although their procurement usually entails great difficulties, both practical and technical.

The suggestions of Doctor of Technical Sciences G. V. Romanovskiy at the current Conference of Aerial Surveys are quite opportune. He proposes the publication of photographic maps of the same or larger scale as a supplement to cartographic maps, and that various organizations be provided with the large-scale photographs which they require for special interpreting without making supplementary photographs of a locality.

3. The carrying out of aerial survey lags behind the requirements of the planning. In the case of a great number of fundamental items, planning proceeds only a little ahead of construction, which necessitates the speedy production of cartographic material for research and basic plans. However, at the present time there is a great delay in carrying out aerial surveys of river valleys.

In connection with this, it is necessary, for the solution of planning-research problems, to complete special surveying and other geodetic operations without waiting for topographic maps, even though these operations increase planning costs and prolong the time. Also, sometimes it is necessary to make inferior intermediate topographic materials or to limit the detail of the projected studies, which lowers the quality of the planning. Such a situation depreciates in actual practice the value of the topographic maps which are subsequently received.

Therefore accelerated methods of making maps must be devised, so that they can be produced in half the time, and in not more than 2 years.

Stereoscopic examination of aerial photographs of river valleys has been used by the Hydroelectric Power Planning Trust for a long time in investigating topographic conditions in connection with the selection of a site for the dam of a hydroelectric power station, and in establishing the general laws of the geological structure of the parts of the construction. However, formerly only the materials of phototheodolite surveys of localities were used for this. Recently they have started to use aerial photos on scales from 1:35,000 to 1:10,000 for these purposes. In the current year, for the first time aerial reconnaissance of river valleys in mountainous districts has been used as a supplement to this examination. Such air reconnaissance was carried out prior to the surveys in connection with designing the set-up for utilization of the water power of the Naryn River in Central Asia. In this same district, selection of one of the dam sites in drawing up the Chatkal River plan was made solely on the basis of stereoscopic studies of aerial photos. Geomorphological maps and maps of tectonic disturbances for the route of a drift tunnel were compiled in connection with surveys for the Dar'yal'skaya Hydroelectric Power Station on the Terek River by means of stereoscopic studies of aerial photos on a scale of 1:34,000. Maps are compiled on a scale of 1:25,000 using a topographic basis on the same scale.

The intermediate products of aerial photo surveys have been successfully used in the solution of various planning problems concerning reservoirs. In particular, the use of enlargements of aerial photos, mosaics, and photomaps of the territory of populated points located on the sides of a reservoir has become widespread in showing the damage due to inundation, and also in investigations providing a forecast of the reworking of banks. Enlargements of 4 to 5 times are done with original material (photographs, charts, photomaps). The enlarged photomaterials are interpreted and a survey of the relief is made within a certain range of the contours near the mark of the normal level of the waterhead. Sometimes field work is done on contact prints, and the enlargement of the photos is done later. The photographs are not rectified. In addition to topographic interpretation, aerial photographs are also used in geological-engineering surveys of the sides of the bowl of a reservoir, and in contouring the geological profile.

The intermediate products of aerial surveys are being used in studies of populated points in many areas of research. Many hundreds of populated points have been covered in this way: the reservoirs of the Nevskaya Hydroelectric Power Station on the Neva River, the Shul'binskaya Hydroelectric Power Station on the Irtysh River, the Cheboksarskaya Hydroelectric Power Station on the Volga River, the Kremenchugskaya Hydroelectric Power Station on the Dnieper River, etc. As a result, a very considerable reduction in time and expense has been achieved.

Stereoscopic studies of aerial photographs are also used in geological-engineering surveys of the territories of mountain reservoirs, on a scale of 1:25,000 and 1:100,000. Among these are the Naryn and Chatkal rivers in Central Asia, the Sulak and Terek in the Caucasus, and others. Flights for cartographic purposes on scales from 1:17,000 to 1:35,000 are carried out. It should be mentioned that some parts cannot be interpreted very accurately because of the presence of large shadows. Transfer of the interpreted elements from the pictures to the maps is accomplished by the simplest methods, using no instruments.

Aerial photos and other intermediate materials (mosaics, etc.) are widely used in planning deforesting operations, the clearing of forest areas subject to being inundated by reservoirs, the preparation of fishing areas, etc.

As regards the complete clearing of forests and the clearing of reservoir beds, specific problems arise in connection with the development and calculation of afforestation differing from ordinary forest management, which obviously requires special methods of using aerial photo material.

We shall introduce some data concerning aerial-topographic operations carried out by the branches of the Hydroelectric Planning Trust. A leading role in this matter is played by the Moscow

branch, which has an excellent stereophotogrammetric section possessing the necessary equipment.

The individual sections of hydroelectric power stations, as well as reservoirs, represent survey objects. In the case of large reservoirs, individual sections, photos for which for some reason have not been provided by the GUGK, are photographed; in the case of small and mountainous reservoirs, the entire area is photographed.

Surveys of hydroelectric power stations are usually on scales of 1:5,000 to 1:10,000. Sections are 100-150 square kilometers in area. The survey of reservoirs is done on a scale of 1:25,000, sometimes 1:10,000. The areas of sections are not more than 500 square kilometers. Aerial surveys are on scales of 1:8,000 to 1:30,000, using a camera with a focal length of 100-200 mm. The surveys mentioned above have been carried out for the Krasnoyarskaya Hydroelectric Power Station on the Yenisei River; the Ust-Ilimskaya Hydroelectric Power Station on the Angara River; in plans for utilization of the energy of the Selengi, Sulak, Naryn, and Chatkal rivers and others.

The usual methods of planimetric and altimetric classification of aerial photos were used in the field-editing procedures. Office analysis was done by the method of differentiation, and stereoscopic plotting of mountain areas by stereoplanigraph.

Strip photography was used for the topographic control of the processing of the plans for the design of the power utilization of mountain rivers (the Sulak River in the Caucasus and the Chatkal in Central Asia). An aerial survey of the Sulak River valley at an altitude of 1,700 meters was made simultaneously with two cameras, with a focal length of 100 mm to compile maps of the whole valley on a scale of 1:25,000, and with a focal length of 200 mm to compile maps of the area of the hydroelectric station on a scale of 1:5,000.

Aerial photography is particularly valuable in studies of mountain rivers. In many areas the possibility of a ground survey is completely out of the question because of the inaccessibility of the region, and a photo-theodolite survey would be very complicated and labor-consuming. Suffice it to say that in the case of some surveys elevations reached 800-1,000 meters. The time required to compile the topographic maps was considerably reduced as a result of the use of aerial photos. The quality of the maps, produced on stereoplanigraphs, is characterized by a mean error of determination of elevations of $\pm$ 1.1 m, with contour intervals every 5 m. Economy in the expenditure of labor and funds is obtained.

Small operations on a combined survey on a scale of 1:10,000 for mosaics and photomaps were conducted at the reservoirs of the Narvskaya Hydroelectric Power Station on the Narova River, the

Votkinskaya Station on the Kama River, the Kaunasskaya Station on the Neman River, etc. The surveys mentioned were usually conducted with materials of aerial surveys performed by other organizations -- agricultural surveys, etc. The area of sections covered by such surveys was not more than 150 square kilometers, but the sections were very long.

Aero-photographic materials in the form of photos and mosaics are also used by sections of the Institute for Hydrological Research for investigations of the winter conditions of rivers.

In conclusion, it must be said that more widespread use of aerial surveys in investigations, notwithstanding their obvious productive and economic effectiveness, is blocked by the complexity of organization for the conduct of these operations -- the requirements for early placing of orders, obtaining permission, the unwarrantedly high cost of aerial survey work, and the shortage of stereophotogrammetric equipment.

The following conclusions may be drawn from what has been said above:

1. The planning of hydroelectric power stations is related to the study of many aspects of the natural conditions of hydrotechnical structures and the expansion of reservoirs in the area.

The great diversity of planning problems, the large area of the territory affected by the building of reservoirs, and the shortened periods of time in which to conduct planning and research operations make necessary the use of accelerated methods in mapping the territories involved, and their study from all angles. The possibility of the many-sided use of aero-photographic materials both for mapping territories and for the conduct of special interpretation makes aerial methods a very effective means for the solution of the complex of planning-research problems which arise in designing a hydroelectric power station. This has been established by the results of the use of aerial survey materials for investigations conducted by the Hydroelectric Power Installations Planning Trust.

2. Aerial surveys may be most widely used for making topographic maps of the areas of reservoirs. The state mapping done by the GUGK is especially valuable for the planning of hydroelectric power stations. However, in the organization of aerial photographic operations, the possibilities and the necessity for making maps of various scales (1:25,000 and 1:10,000), for special interpretations (geologic, forest-appraisal, etc.), and also the necessity for using the intermediate products of aerial surveys in the investigations, is not given sufficient consideration. The needs of the users of aerial photographic materials have not been properly studied and have not crystallized. The time required for aerial survey operations and the making of topographic maps is very protracted. Receiving the maps too late depreciates their value for practical use.

3. The following are necessary in order to eliminate the defects listed:

a) Development of the possibilities of the combined use of the materials of aerial surveys of river valleys for the purpose of making maps on scales of 1:25,000 and 1:10,000 from the materials of one flight, and of working out corresponding technologies of production; also for the purpose of special interpretations of aerial photos for geologic, forest-assessment, and similar studies of the needs of the users of aerial survey materials with discussion of them at special conferences, and the development of aerial survey methods providing the best solutions to these problems; also for the purpose of the use of the intermediate products of aerial surveys for engineering investigation.

b) The orderly and systematic provision to the users of topographic maps and aerial survey products, of all the necessary types of intermediate products -- aerial photographs, enlargements of photos, mosaics, photomaps, etc.

c) Development of technological plans providing for the production of maps within a period of not more than 2 years.

4. The Hydroelectric Power Installations Planning Trust has made some progress in the application of aerial surveying for hydrotechnical investigations both for map making and for the special use of aerial survey materials in connection with the study of the natural conditions in the construction areas of hydroelectric power stations.

Nevertheless, wide use of aerial methods in practical investigations has not been achieved, notwithstanding its obvious effectiveness. The principal reasons for the slow introduction of aerial surveys in the conduct of hydrotechnical investigations are the complexity of organization for the timely conduct of aerial survey operations and their excessively high cost, the shortage and still relatively small productive capacity of stereophotogrammetric equipment.

5. The following are necessary for the more wide-spread application of aerial methods in investigations for the design of hydroelectric stations:

a) The creation of conditions for the provision of greater effectiveness in the execution of aerial surveying operations in the required time.

b) Reduction of the cost of aerial operations.

c) The provision of possibilities for acquiring modern efficient stereophotogrammetric devices, in particular general-purpose equipment of native construction, and also the best types of equipment of foreign manufacture.

d) Elimination of the difficulties in obtaining the intermediate products of the aerial surveys of the GUGK.

Hydroelectric Power Installations Planning Trust

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